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Metabolic Activity of Micromycetes Affecting Urban Concrete Constructions

Kazan Federal University, 420008, Kremlevskaya 18, Kazan, Russia

Abstract

© 2018 Galina Yakovleva et al. Concrete resistance to the destructive action of microorganisms is considered as a measure of its durability and is increasingly being raised as an important issue. We focused our study on the biodeterioration of concrete specimens widely used as a building material of urban houses by micromycetes isolated from the inner wall surface of the former military hospital in Kazan city, Tatarstan, Russia. Fungal community consists of 9 Penicillium isolates, 6 Aspergillus, 2 Trichoderma, and 1 isolate of Alternaria. First, we have identified two dominant isolates, Aspergillus fumigatus and Penicillium brevicompactum, and characterized their destructive properties according to the radial growth rate, antagonistic activity towards bacterial habitants of concrete, and production of organic acids. Then, we have demonstrated that five tested brands of high-strength concrete differ in bioreceptivity. The alterations in concrete resistances to compression and flexure after fungal attack were recorded at the trend level, mainly due to a short exposure time of concrete to fungal destructors in tests recommended by national Russian standard. Finally, using scanning electron microscopy we have shown that colonization of concrete by the dominant fungi includes their penetration into the thickness of concrete and germination in cracks. Elementary analysis revealed the decrease of calcium content on about 41% after fungal growth on the concrete in liquid phase and on 32% by superficial growth in comparison with the samples without fungal treatment.

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References

[1] D. Allsopp, K. J. Seal, and C. C. Gaylarde, Introduction to Biodeterioration, Cambridge University Press, 2nd edition, 2006.

[2] O. Aviam, G. Bar-Nes, Y. Zeiri, and A. Sivan, "Accelerated biodegradation of cement by sulfur-oxidizing bacteria as a bioassay for evaluating immobilization of low-level radioactive waste, " Applied and Environmental Microbiology, vol. 70, no. 10, pp. 6031-6036, 2004.

[3] E. Bastidas-Arteaga, M. Sánchez-Silva, A. Chateauneuf, and M. R. Silva, "Coupled reliabilitymodel of biodeterioration, chloride ingress and cracking for reinforced concrete structures, " Structural Safety, vol. 30, no. 2, pp. 110-129, 2008.

[4] M. Sanchez-Silva and D. V. Rosowsky, "Biodeterioration of construction materials: State of the art and future challenges, " Journal of Materials in Civil Engineering, vol. 20, no. 5, pp. 352-365, 2008.

[5] S. Wei, Z. Jiang, H. Liu, D. Zhou, and M. Sanchez-Silva, "Microbiologically induced deterioration of concrete: a review, " Brazilian Journal of Microbiology, vol. 44, no. 4, pp. 1001-1007, 2013.

[6] R. Rogers, "Effects of Microbially Influenced Degradation on Massive Geothermal Field Concrete Structures, " Corrosion Reviews, vol. 17, no. 3-4, 1999.

[7] S. Nasrazadani and E. Sudoi, "A Review of biodeterioration of concrete structures. ID NACE-10216. Publisher NACE International Source CORROSION 2010, 14-18 March, " in ID NACE-10216. Publisher NACE International Source CORROSION 2010, San Antonio, Texas, 2010, https://store. nace. org/3aa1b8b4-2859-df11-a-21-005056ac759b.

[8] P. K. Mehta, Concrete in the marine environment, Taylor & Frances, 2005.

[9] M. R. Silva and T. R. Naik, "Biodeterioration of concrete structures in coastal zone, " in Proceedings of the ird International Conference on Sustainable Construction Materials and Technologies, Kyoto Research Park, Kyoto, 2013, http://www. claisse. info/2013%20papers/data/e418. pdf.

[10] B. Cwalina, "Biodeterioration of concrete, " Architecture Civil Engineering Environment, vol. 4, pp. 133-140, 2008.

[11] K. J. Martin and P. T. Rygiewicz, "Fungal-specific PCR primers developed for analysis of the ITS region of environmental DNA extracts, " BMC Microbiology, vol. 5, article no. 28, 2005.

[12] W. M. Reuter, the analysis of a broad range of organic acids by HPLC with UV detection: application brief. Shelton: PerkinElmer, 2015, https://www. perkinelmer. com/lab-solutions/ resources/docs/APP Analysis-o--Chlorophenols-in-Water-by-UHPLC-with-PDA-Detection-012442 01. pdf.

[13] G. Y. Yakovleva, A. R. Zajnullina, V. F. Stroganov et al., "Assessment of biodamage resistance of various concrete grades, " International Journal of Pharmacy and Technology, vol. 8, no. 4, pp. 24291-24299, 2016, http://www. ijptonline. com/wp-content/ uploads/2017/01/24291-24299. pdf.

[14] V. F. Stroganov and E. V. Sagadeev, Biodeterioration of building materials, ConstructionMaterials, Moscow, Russia, 2015.

[15] S. L. Goss, K. A. Lemons, J. E. Kerstetter, and R. H. Bogner, " Determination of calciumsalt solubilitywith changes in pHand P, " Journal of Pharmacy and Pharmacology, vol. 59, no. 11, pp. 1485-1492, 2007.

[16] M. Ijdo, N. Schtickzelle, S. Cranenbrouck, and S. Declerck, "Do arbuscular mycorrhizal fungi with contrasting life-history strategies differ in their responses to repeated defoliation?" FEMS Microbiology Ecology, vol. 72, no. 1, pp. 114-122, 2010.

[17] M. A. Shirakawa, C. C. Gaylarde, P. M. Gaylarde, V. John, and W. Gambale, "Fungal colonization and succession on newly painted buildings and the effect of biocide, " FEMSMicrobiology Ecology, vol. 39, no. 2, pp. 165-173, 2002.

[18] N. Heutte, V. André, C. DubosArvis et al., "Assessment ofmulticontaminant exposure in a cancer treatment center: a 2-year monitoring of molds, mycotoxins, endotoxins, and glucans in bioaerosols, " Environmental Modeling & Assessment, vol. 189, no. 1, 2017.

[19] G. M. Gadd, "The geomycology of elemental cycling and transformations in the environment, " Microbiology Spectrum, vol. 5, no. 1, 2017.

[20] S. Okabe, M. Odagiri, T. Ito, and H. Satoh, "Succession of sulfuroxidizing bacteria in the microbial community on corroding concrete in sewer systems, " Applied and Environmental Microbiology, vol. 73, no. 3, pp. 971-980, 2007.

[21] C. Gaylarde, J. A. Baptista-Neto, A. Ogawa, M. Kowalski, S. Celikkol-Aydin, and I. Beech, "Epilithic and endolithicmicroorganisms and deterioration on stone church facades subject to urban pollution in a sub-tropical climate, " Biofouling, vol. 33, no. 2, pp. 113-127, 2017.

[22] D. J. Giannantonio, J. C. Kurth, K. E. Kurtis, and P. A. Sobecky, "Molecular characterizations of microbial communities fouling painted and unpainted concrete structures, " International Biodeterioration & Biodegradation, vol. 63, no. 1, pp. 30-40, 2009.

[23] T. C. Dakal and S. S. Cameotra, "Microbially induced deterioration of architectural heritages: Routes and mechanisms involved, " Environmental Sciences Europe, vol. 24, no. 1, 2012.

[24] M. O. Fomina, S. V. Olishevs'ka, V. M. Kadoshnikov, B. P. Zlobenko, and V. S. Pidhors'kyi, "Colonization and destruction of concrete by mitosporic fungi in model experiment, " Mikrobiol Z, vol. 67, no. 2, pp. 96-104, 2005, https://www. ncbi. nlm. nih. gov/pubmed/16018222.

[25] M. A. Coombes, H. A. Viles, L. A. Naylor, and E. C. La Marca, "Cool barnacles: Do common biogenic structures enhance or retard rates of deterioration of intertidal rocks and concrete?" Science of the Total Environment, vol. 580, pp. 1034-1045, 2017.

[26] M. Gonzalez-Munoz, "Bacterial biomineralization applied to the protection-consolidation of ornamental stone: current development and perspectives, " Coalition, vol. 15, pp. 12-18, 2008, http://www. rtphc. csic. es/issues/15 4. pdf.

[27] J. J. Soko?owska and P. Woyciechowski, "Effect of acidic environments on cement concrete degradation, " in Proceedings of the ird International Conference on Sustainable Construction Materials and Technologies, Kyoto Research Park, Kyoto, Japan, 2013, http://www. claisse. info/2013%20papers/data/e085. pdf.

[28] M. Ndagijimana, C. Chaves-López, A. Corsetti et al., "Growth and metabolites production by Penicillium brevicompactumin yoghurt, " International Journal of FoodMicrobiology, vol. 127, no. 3, pp. 276-283, 2008.

[29] L. Kupski, M. Freitas, D. Ribeiro, E. B. Furlong, and E. Fernandes, "Ochratoxin A activates neutrophils and kills these cells through necrosis, an effect eliminated through its conversion into ochratoxin ?, " Toxicology, vol. 368-369, pp. 91-102, 2016.

[30] B. Aleksic, M. Draghi, S. Ritoux et al., "Aerosolization of Mycotoxins after Growth of Toxinogenic Fungi on Wallpaper, " Applied and Environmental Microbiology, vol. 83, no. 16, 2017.

[31] S. Joshi, "The sick building syndrome, " Indian Journal of Occupational and Environmental Medicine, vol. 12, no. 2, p. 61, 2008.